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WORKING DRAFT

The Decision Module
Working Paper

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The decision module for the simulation will be disigned to provide country specific input values of variables to each of the three sector modules, oil, agriculture, and human resources. For the purpose of the decision module, nations will be conceptualized as goal seeking systems. Thus the mix of input variables and their values represent a choice of inputs that the decision-makers perceive to be relevant to controlling their perceived environment with respect to a desired environmental state. Using this notion of the nation, any analytic representation of the decision process must deal with two classes of problems: 1) What are the goals of the decision-makers and how do they change over time and 2) Given the goals of the decision-makers, how are they transformed into values of manipulable variables?

The class of issues dealing with goal specification and goal change has received very little attention in the literature on the analysis of choice situations. It has generally been the case that the goals of the decision-makers have been specified as initial assumptions and are taken to be static over time, i.e., utility maximization given pre-assigned utilities to various outcomes. While in some situations that assumption is useful, in others it is not. In the case of the five oil producing nations, the goals are not totally static. While for the most part the basic goals or values of the nation do not change (i,e, survival) more specific goals or operational goals are not strictly determined from the unchanging basic values or norms. Influences both within the nation and outside the nation may increase or decrease the importance of certain operational goals without changing the basic goal structure. One possible approach for dealing with changing short-term goals discussed below, is taken from Bossel and Hughes' "Simulation for Value Controlled Decision Making: Approach and Prototype" (1973), done in context of the Mesarovic - Pestel World Model Project.

The issues dealing with the choice of manipulable variables and their values given the goals has received considerably more attention. The main problems to be solved in this respect concern the development of a suitable representation for 1) the choices available to the decision-makers; 2) the subset of those possible choices perceived as relevant in a given situation; and 3) the means by which the alternatives and the goals are translated into actual choices. The representation of these three elements that is currently being considered is a spatial model of the possible choices with a Markov process interpretation of the actual choice from the alternatives. This representation is drawn largely from the works of Nelson and Winter (1972, 1973) and Nelson, Winter, and Schuette (1973) on evolutionary economic growth models.

The discussion of the two components of the decision module that follows should be considered as provisional solutions to the problems outlined above.

In dealing with the problems of changing goals in a decision situation, Bossel and Hughes have conceptualized goals as being at the base of a hierarchically structured value network. At the top of the structure are superior values (i.e., survival). These superior values are relatively unchanging and support the remainder of the structure. Between the superior values and the operational goals are, in Bossel and Hughes' terms, "inferior values". It is the inferior values that link the specific goals to the general values, (See Figure 1, from Bossel and Hughes (1973)). Imposed on this norm structure are weights specifying the importance of the values and goals to the decision-makers. While the structure can be determined without reference to the norm weights, weights are necessary for decision making whenever more than one operational goal must be considered at the same time. In essence, the weights on the operational goals rank the goals in terms of importance. The weights of the values represent the importance of the content (i.e., resource usage) of the value to the system. To introduce a dynamic quality to the value structure, Bossel and Hughes use the concept of monitor variables. Monitor variables represent the perceptions of the environment by the decision-makers. Perceived changes in the monitor variables are responsible for changes in the weights and content of the operational goals.

For example, consider resource usage in a value structure. In Figure 1, resource usage would have a high weight because of its importance to the system, even if a variable monitoring

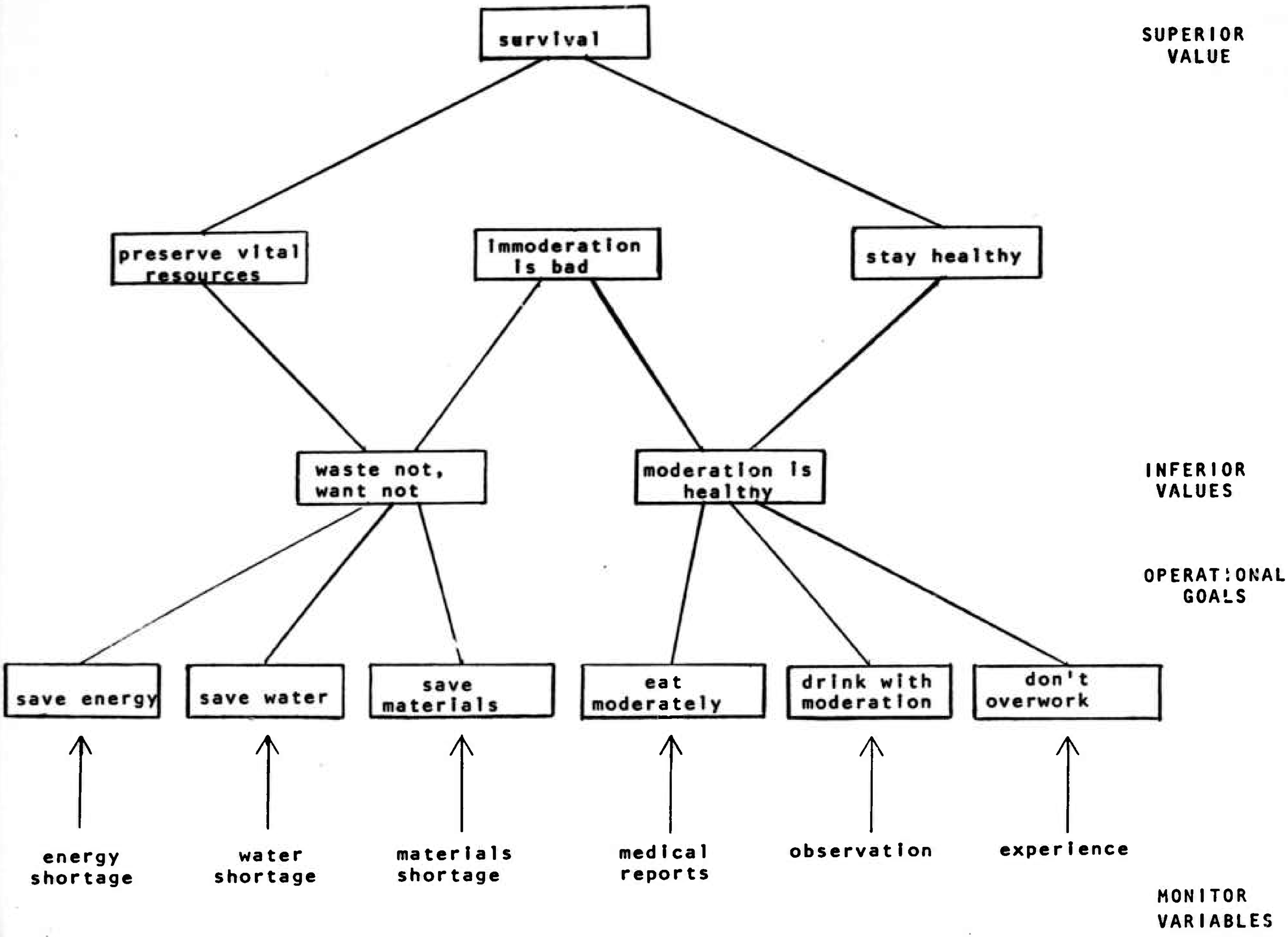


Figure 1 - Sample Norms Structure

fresh water supply indicated abundance. But in the case of abundance of water, the content (i.e., desired water conservation rate) of the operational goal would be smaller, as would the importance of that goal in relation to other goals in the system. As Bossel and Hughes have conceptualized it, changes in monitor variables cause changes in operating goals (i.e. specific desired levels of the goals) mediated through the value network.

In order for this formulation of the normative component of decision making to be used, the monitor variables, values, and goals of the country decision systems will have to be identified, along with the coefficients of weight and influence which relate changes in values of monitor variables to changes in values and goals. Once suitable values for the above quantities have been determined, the system must be evaluated in terms of sensitivity to small changes in the coefficients linking inputs to outputs. If it is the case that the system's output is very sensitive to the values of the coefficients, the representation may not prove workable, since the estimations will necessarily have a high chance of measurement error associated with them. Even if the problems associated with parameter estimation can be dealt with, the system must still be examined to determine whether or not the outputs (i.e., the goal changes, contents, and weights) look reasonable given the inputs and what is known about the system to be modeled. Until that analysis of the system has been completed, the particular formulation of goal change must be considered provisional.

Assuming that the problems dealing with goal specification and change have been dealt with satisfactorily, the class of issues outlined above, dealing with the translation of goals and possible choices into decisions, must be confronted. The current state of the representation of the possible choices open to the decision-makers involves a spatial approach, where each dimension defining the space represents all of the possible values of a manipulable variable can be represented as a point in the space. While in principle there are an infinite number of points in the space, the number and character of the points or alternatives that a nation can choose is limited by technological boundaries, and within the set of technologically feasable points, we assume there to be a finite number of points.

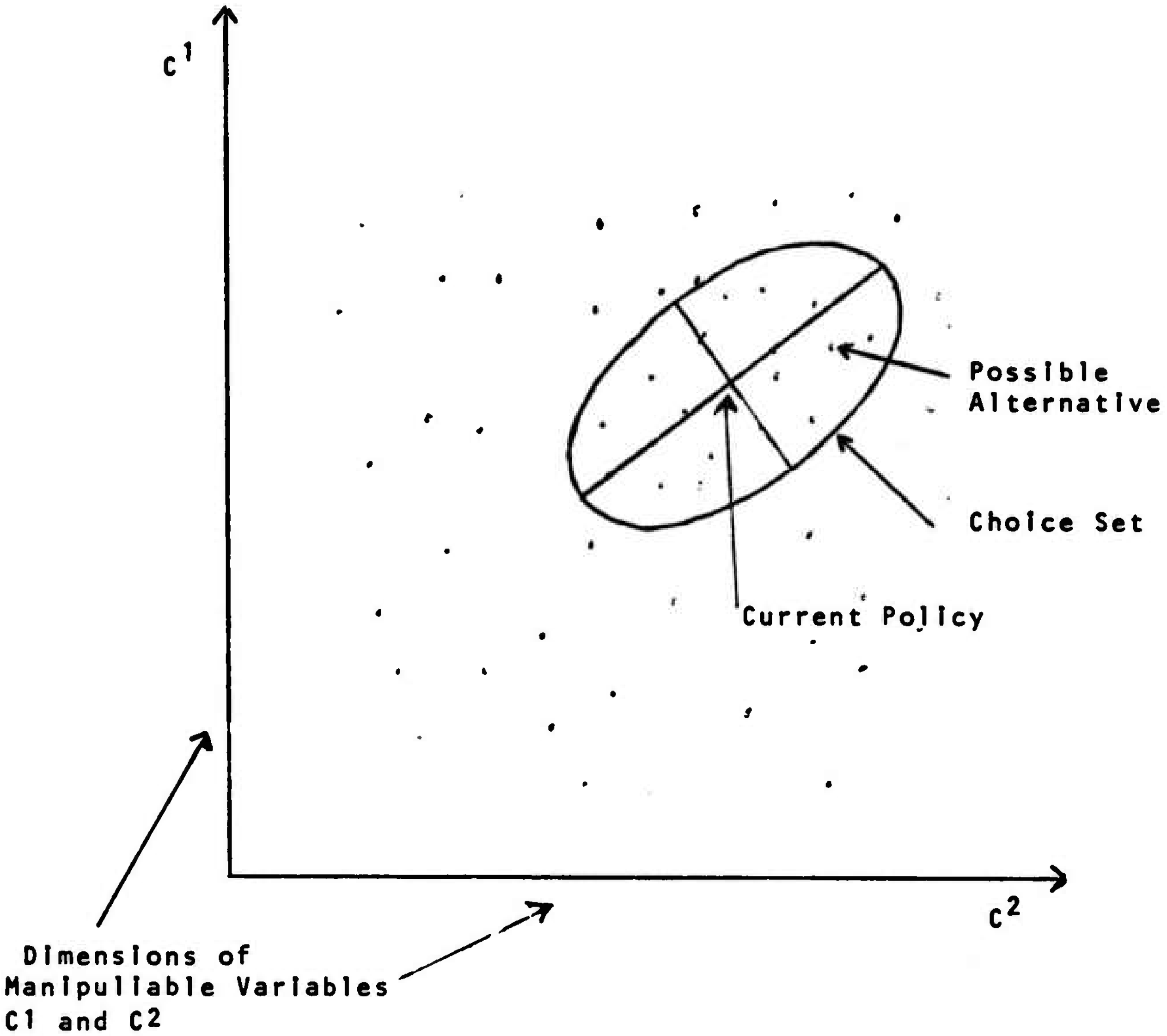
While it is often the case in analyses of decision situations that decision-makers are defined as rational in the sense of considering all possible alternatives and choosing that alternative that maximizes their goals, when attempting to deal with real decision-makers' behavior, that assumption has shown to be of little help (Cf. Simon, 1955). In attempting to deal with the behavior of decision-makers, the concept of bounded rationality or satisficing behavior is introduced. It is argued that when decision-makers search for an alternative to their present policy, they 1) consider only a limited number of possible alternatives; and 2) they only search for alternatives until an alternative decreases the difference between the projected state of the environment after implementation of the decision, and their preferred state to an acceptable level. Search for an alternative within the decision space is primarily a function of 1) prior experience; 2) dissatisfaction with the current policy; and 3) the distance, measured in the alternative or choice space, between the current policy and some alternative policy. In both works of Bossel and Hughes, and Nelson, Winter, and Schuette, the greater the dissatisfaction of the decision-makers with the current state of the environment, the further will be the search from the current policy point. If dissatisfaction is low, only those points close to the current policy will be considered. On the other hand, the greater the dissatisfaction is with the current policy, the greater the distance will be from the current point of the search. This does not imply that given a high dissatisfaction measure, the new policy choice will be a great distance from the current policy -- only that the search area will be larger. Thus, dissatisfaction and distance combine to identify those points or policies in the choice space that will be considered as alternatives.

While dissatisfaction controls the length of the search, the past experiences of the decision-makers influence the direction of the search within the choice space. As is illustrated in Figure II, the decision-makers may learn that movement along one dimension (C_2) may have more affect on the performance of the environment to be controlled then movement along another dimension. In this context, learning is indicated by the shape and position of the choice or alternative set. At the present time, work is being done on the method of determining the shape and position of the alternative set. Once it can be determined what the alternatives the decision-makers will consider in a given situation, the concept of choice can be explicated.

The current representation of the act of choice is conceptualized as a stochastic process. Drawing from the works of Nelson and Winter, and Nelson, Winter and Schuette, the possible choices are considered as states in a Markov chain process. Given the current policy, there is a vector whose components are the probabilities of considering a particular policy as an alternative to the current policy. The probability is not the probability of actually choosing the point as an alternative, but only of considering the point as a possible alternative to the current policy.

The last issue regarding the decision process to be dealt with concerns the process by which a policy is accepted or rejected as a feasible alternative to the current policy. One option would be to give the decision-makers full and accurate forecasting powers--but as was discussed above, the characterization of man as completely rational is not des-

FIGURE II


C^1
Possible
Alternative
Choice Set
Current Policy
C^2
Dimensions of
Manipuliable Variables
C1 and C2

criptive of reality. On the other hand, by denying the decision-makers any forecasting powers, the probability of consideration could equal the probability of adoption. In certain circumstances this latter operation may be acceptable, but in others it is as untrue of reality as the totally rational formulation. At the present time, this issue is just beginning to be resolved.

Once the method of adoption of alternatives has been decided upon, the decision module would implement the chosen mix of input variables, observe the performance of the various sectors, and re-evaluate the policy in terms of the goals of the system.

As we indicated above, work on the decision module is proceeding on several levels: 1) the issues of goal specification; 2) the issues of goal change; 3) the specification of alternatives; 4) the evaluation of alternative policies with respect to the goals; and 5) the adoption of a specific policy. Once we have arrived at some resolution to the above issues, the process of interfacing the decision module with the sector modules can be implemented and the process of testing begun.

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